

CBS TELEVISION NETWORK

SIMPLIFIED OPERATING PRACTICES FOR
STUDIO CAMERAS

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It would be nice if, in the image conversion process, all television images improved as much as this, but the fact is, they do not. The conversion of an object into a television image, a photographic image, or into any other type of image for that matter, is not effected without some loss of quality. Each imaging system has shortcomings which limit its quality, but despite these, it is possible, with care, to produce pictures which are a good illusion of reality. For example, which one of these candlesticks is real? The advent of the $4\frac{1}{2}$ " image orthicon camera has made it possible to achieve results vastly superior to those possible with older cameras.

To appreciate how this happens, we must consider how image quality is judged. In the case of the monochrome, or black-and-white television system, its quality is specified by three characteristics:

- (1) Resolution or sharpness,
- (2) Noise or graininess, and
- (3) Tone scale and contrast range.

The $4\frac{1}{2}$ " camera provides inherent improvement in each of these and makes it possible to achieve pictures with acceptable sharpness and noise without excessive overexposure so typical of early cameras.

This 3" picture, for example, may be familiar; but, despite this, it is still poor photography. The gray scale is distorted, and the picture is marred by halos like these off this white block. And, in short, the picture is a poor representation of this scene.

The $4\frac{1}{2}$ " tube, on the other hand, with inherently better resolution and lower noise, allows operation with less overexposure, providing a more uniform, pleasing tonal scale. In this film, operating practices which fully exploit the $4\frac{1}{2}$ " tube capabilities will be described and demonstrated. Special emphasis will be given to the interrelationships between scene contrast, lighting, and camera exposure.

To begin with, a basic understanding of the television imaging process is required. The monochrome television system converts colored blocks like these gray blocks into tones of gray, the lightness or darkness of which is a product of the light incident on them and of their reflectance. If we look at the electronic waveform generated by the blocks, we can see that the dark block appears here in the lower black region, the lighter block here in the high white region, and the gray block here, with the background tones here. As we add whiter blocks, the wave form shows higher voltage in the high white level, but there is a point beyond which whiter blocks would not produce higher white voltages. That point is more graphically described on this chart. This chart shows how black-to-white object tones transfer through the system to become image tones. The object brightnesses are shown along the bottom, increasing in equal increments to the right, and the resulting image brightnesses increasing upwards. The television system is represented by this "S" shaped curve. Notice that there is only a limited range where the image brightnesses are proportioned to the original object. Above this point, and below it, the curve begins to "flatten", causing compression of the white tones and of

the black tones. Thus, if the television camera is pointed at an object with excessive contrast, those tone values above this point and below it will be distorted and lost.

To demonstrate this, we are going to look at a gray scale chart with a 20:1 contrast range. That is, the whitest chip is exactly 20 times brighter than the blackest chip. If we look at the waveform of this chart, you can see all the tone values from black to white are reproduced.

When this chart is replaced with one having a 1000:1 contrast range, far in excess of the system's ability to reproduce, a less satisfactory image results. The waveform exhibits the "S" shape of the graph. There is a linear portion above and below which there is severe compression of the black and white tones. The position of this linear range can be altered by altering the camera exposure, but it cannot be extended. To illustrate this, the camera exposure will be reduced by 2 "f" stops. As this is done, the white range becomes less compressed, showing more white tones, but the black range becomes more compressed and is completely lost. The range has been changed but has not been extended. Conversely, if the camera exposure is increased from the original by 1 "f" stop, the black range is opened, but only at the sacrifice of the white range, which becomes more compressed.

So far, it is our experience that efforts to extend the contrast range by adding black stretch to the circuit have introduced too much noise to be of practical use. Thus, under normal circumstances, the system cannot reproduce scene contrasts in excess of

about 40:1, and probably 20:1 is a more workable figure.

Within the framework of this limited contrast handling capacity, it is possible to create the full range of artistic effects and dramatic moods, as long as limitations are recognized and practices adopted to satisfy them. In general, these practices relate to three areas:

- (1) Staging and scenic design,
- (2) Lighting, and
- (3) Camera exposure.

In regard to the first of these, the contrast of settings and properties should be limited and extremes avoided. The human face with a reflectance which varies from about 30% to 40% is the most important and most recognizable object in most scenes. It, therefore, sets the point above and below which other scenic elements must fall.

Extremely white clothing, paint, paper, and other bright objects like this background, should be avoided. They distract from the face and make it dark. Pastel or colored backgrounds should have been used in this scene.

Similarly, dark or black clothing, furniture, and settings like this should be avoided where detail is to be seen. To see the detail in this background, the camera exposure must be opened. When this is done, the background detail is visible, but the face is badly overexposed.

As an aid, scenic paints can be calibrated by relating them to a

standard gray scale observed over the television system. Small pocket gray scales of the type used by CBS, like this one, are useful guides in the selection of props and graphics.

Secondly, lighting and contrasts and ratios should be limited. Present camera tube sensitivity is such that the amount of light is not as critical as the correct range and balance of light between the highlights and lowlights.

Don't overlight like this scene. Good modeling and back light, which add a three dimensional effect to an otherwise flat television picture, can be achieved with lighting ratios well within the system's requirements. A light meter is helpful to evaluate the incident light on a scene and to be able to balance from scene to scene.

When the scenic elements and their lighting are combined on stage, the camera sees the product of the two. If either one is incorrect, it will affect the other and may damage the result.

For example, a setting like these blocks with inherently high contrast will restrict lighting flexibility. As the waveform shows, this scene permits no margin for lighting expression. With only flat lighting on them, the full range is produced by the contrast inherent in the objects alone. Any effort to "key" or "model" with light tends to reduce the range if applied to the dark blocks, and tends to exceed the range, compress, and cause halos if applied to the light blocks.

To demonstrate the full range of artistic effects that can be

achieved with the proper contrast range, we are going to look at some actual scenes. This interior setting represents a scene with brightness values equally distributed between the black and the white regions. The light on this scene is 120 foot-candles in the maximum key light areas. The waveform shows the highlights here in the near white region, the flesh tones of the performers here, and the dark tones in the near black region.

The patio, although lit with the same total key light, has been re-balanced to simulate a sun-lit exterior with a single light source effect. The waveform shows a full distribution of black-to-white values. The flesh tones have been lifted higher than before, but still well within the proper contrast range.

If we turn off the sun, we can simulate a low-key moonlight effect which, again, is still lit with the same total key light. The waveform of this scene shows the bulk of the information in the mid-gray to black region, the flesh tones here, a little bit lower than before, and the white details at the reference white level.

Similar techniques are used in an interior night scene. However, without a single source of illumination like moonlight to depend on, the illusion of darkness is heightened by the use of practical lamps, and by the suggestion that the scene outside is darker than the inside. The waveform of this scene shows the distribution of gray values much the same as before, with a full black-to-white range.

All of these scenes used the same total light in the highlight areas. The effects are created by properly balancing the light. "Low key" scenes are not made by turning out all the lights, nor are "high key" scenes made by "pouring-on" the light. In fact, the amount of light in foot-candles has nothing to do with the effects. Within limits, it merely determines the camera exposure. We can demonstrate this, since, once the correct lighting balance has been established, the incident light level can be exchanged for camera exposure. The light on this scene is 125 foot-candles, as shown on the meter, in the base plus key areas. If we lower the light to half that value, or about 64 foot-candles, the scene becomes dark and underexposed. If the iris of the "taking" camera is now inserted in the upper right-hand corner of the picture and the camera exposure increased by exactly one "f" stop, the scene returns to its original value.

By repeating this procedure and lowering the light from 64 foot-candles to 32 foot-candles, the scene again becomes dark and underexposed. If the camera exposure is increased again by one more "f" stop, the scene returns to its original value, and we have changed nothing but the incident light value and the camera exposure.

By repeating the procedure once again and lowering the light from 32 foot-candles to 16 foot-candles, the scene again becomes dark and underexposed, but increasing the camera exposure by one additional "f" stop will return the scene to its original value. We are now using 16 foot-candles, or less light than that present in the average living room, yet nothing in the scene has changed except the depth-of-focus. As you can see, background objects are going out

of focus in order to keep the performers in the foreground in focus. While 16 foot-candles may not be a workable light level for studio use, it does demonstrate that the absolute level of the light in a scene is only a function of camera exposure and sensitivity--the important factor is the contrast range and balance of light between the highlights and lowlights.

So far, we have examined the limited contrast handling capacity of the television system and the "on stage" practices which are required to produce quality results. But, before these "on stage" controls can be effective, the cameras must exhibit consistent operating characteristics from day to day. One method to insure consistent operation is to standardize the camera using gray scale charts like this. But, in order to understand these charts and their use in camera calibration, we must first divide the television system into its basic components. In its simplest form, the television system consists of a camera, a transmission system, and a television monitor. When operating properly, the transmission system simply delivers the video signal without modification or distortion from the camera to the picture monitor. The picture tube in the television monitor transfers the video signal into a visible picture by a transfer characteristic like this chart. The curve exhibits a very steep linear portion which causes an expansion of the white tones compared to the original object tones. As the curve flattens off, it causes severe compression of the black tones. In order to achieve an overall transfer which will yield an image that looks like the original object, compensating adjustments must be made elsewhere in the

system. The black tones must be expanded, and the white tones must be compressed. These adjustments are made in the "taking" camera. The transfer characteristic of the camera is modified so that the black tones of the scene are expanded and the white tones are compressed. This is accomplished by either slightly overexposing the image orthicon and operating over the "knee" of its characteristic, or by the use of nonlinear amplifiers to "stretch" the black values.

To make it possible to adjust and maintain the camera transfer characteristic on a day-to-day basis, this test chart has been standardized by the EIA and devised such that each step is 1.4 times brighter than the previous step. The chart is lit with a flat light equal to the intensity of the total scene light to be used. The camera is then exposed on this chart, and the exposure adjusted so that the steps on the waveform appear to be straight or linear. When this is done, the camera is automatically adjusted so that the black tones are stretched and the white tones are compressed, making the necessary compensation for the opposite effect of the kinescope picture tube. To illustrate this, we will replace this chart with another chart which has the same contrast range but whose steps have been designed to have equal increments of brightness from step to step. The waveform shows the expanded values in the black area and the compressed values in the white area. This linear chart is used to demonstrate the shape of the corrected transfer characteristic. The log chart is the one normally used for camera calibration on a day-to-day basis.

All the efforts to maintain "on stage" control of scenic contrasts

and lighting and to maintain standardized camera conditions will still be ineffective if the video waveform is not properly interpreted and related to the scene pictures. The waveform monitor is a tool to aid in the production of good pictures but, improperly interpreted, it can damage the entire creative effort.

We are going to look at another scene which has a normal range of contrasts from black to white. The waveform of this scene would probably not lead to any confusion. However, as the camera pulls back to reveal the white table top, the waveform shows the excessive white level. If the video operator permits this white surface to determine his white video level, the rest of the scene becomes dark and uninteresting. When a tablecloth of proper tone value is placed on the table, the scene returns to normal. Large area errors like this, however, don't happen as often, in a well controlled operation, as do errors resulting from misinterpretations of small specular details or "glints" such as those from the glassware being placed on the table. As can be seen on the waveform, the small specular highlights from the glassware are far in excess of the normal contrast range of the system and are being clipped off at reference white. If these specular highlights are permitted to determine camera exposure or video gain, the scene again becomes dark and uninteresting. However, looking only at the waveform monitor, and not the picture, it could appear that this scene has a full distribution of tone values all the way from black to white, but, as you can see, the picture is dark and underexposed. As we return to normal, the scene brightens up and the interest in it picks up, yet the highlights off

the glassware are still visible and still effective in showing that the glassware is glass. Proper interpretation of picture and waveform information is vital in order to make small variations in exposure and channel gain necessary throughout a production.

The video operator must be able to judge when an adjustment is necessary, and which adjustment is necessary.

Exposure adjustments are a function of small lighting variations from scene to scene, but gain adjustments are required due to electron redistribution effects resulting from the slight amount of overexposure used to correct the camera transfer characteristic. Even though this is less than one "f" stop, it causes enough redistribution in the image orthicon to cause changes in the channel gain as a function of the size and distribution of the black-and-white information in the scene. To demonstrate this, we are going to pull back from this full frame shot of the gray scale chart while watching the waveform and making no adjustments to the camera. As the white and black chips become a smaller and smaller part of the total scene area, the video level on the waveform monitor rises. Thus, during a production, small changes in channel gain must be made to compensate from wide shots to close-ups, and, in the final analysis, video operation is as important to control as the other elements.

The television system can produce pleasing results despite its limitations, but this can only be accomplished when every component involved is controlled to satisfy the system's requirements. Scene contrasts must be restricted. Lighting ratios must be balanced.

Cameras must be calibrated objectively to present consistent operating conditions from day to day.

The full range of artistic expression can be achieved within these limitations, but those who ignore them injure their product and ultimately reduce the value of their effort. The skill of a television artist, as of that artist in any medium, is measured by his ability to work within the system, and not by his failure to do so. The limitations of any imaging system should be looked on as a challenge to ingenuity and not as a frustration to artistic ability.